

Local Control of Blood Flow by the Tissues

One of the most fundamental principles of circulatory function is the ability of each tissue to control its own local blood flow in proportion to its metabolic needs.

Mechanisms of Blood Flow Control

Local blood flow control can be divided into two phases:

(1) acute control and (2) long-term control.

*Acute control is occurring within seconds to minutes to provide very rapid maintenance of appropriate local tissue blood flow.

*Long-term control means slow, controlled changes in flow over a period of days, weeks, or even months. In general, these long-term changes provide even better control of the flow in proportion to theneeds of the tissues.

Acute Control of Local Blood Flow

1)Effect of Tissue Metabolism on Local Blood Flow:increase in metabolism up to eight times normal increases the blood flow acutely about fourfold.

2)Acute Local Blood Flow Regulation When Oxygen Availability Changes. One of the most necessary of the metabolic nutrients is oxygen. Whenever the availability of oxygen to tissues decreases,such as

* (1) at high altitude at the top of a high mountain(hypoxia)

* (2) in pulmonary disease(pneumonia).

(3) in carbon monoxide poisoning (which poisons theability of hemoglobin to transport oxygen).

(4) in cyanide poisoning (which poisons the ability of the

tissues to use oxygen).

There are two basic theories for the regulation of local blood flow when either the rate of tissue metabolism changes or the availability of oxygen changes.They are (1) the vasodilator theory and (2) the oxygen lack theory.

Vasodilator Theory for Acute Local Blood Flow Regulation

According to this theory, the greater the rate of metabolism or the less the availability of oxygen or some other nutrients to a tissue, the greater the rate of formation of vasodilator substances in the tissue cells. Some ofthe different vasodilator substances that have been suggested are adenosine, carbon dioxide,* adenosine*,phosphate compounds, histamine, potassium ions, and hydrogen ions.

Most of the vasodilator theories assume that the vasodilator substance is released from the tissue mainly in response to oxygen deficiency.

decreased availability ofoxygen can cause both adenosine and lactic acid (containinghydrogen ions) to be released into the spaces between the tissue cells; these substances then cause intense acute vasodilation which leads to increase local blood flow toward normal.

Oxygen Lack Theory for Local Blood Flow Control

which can be called either the oxygen lack theory or, more accurately, the nutrient lack theory (because other nutrients besides oxygen are involved). Oxygen (and other nutrients as well) is required as one of the metabolic nutrients to cause vascular muscle contraction. Therefore, in the absence of adequate oxygen, it is reasonable to believe that the blood vessels simply would relaxand therefore naturally dilate. Also, increased utilization of oxygen in the tissues as a result of increased metabolism theoretically could decrease the availability of oxygen to the smooth muscle fibers in thelocal blood vessels, and this, too, would cause local vasodilation.

Example: Beriberi(vitamins deficiency diseases)*

in which the patient has deficiencies of the vitamin B substances thiamine, niacin, and riboflavin. deficiency of these vitamins might lead to diminishes smooth muscle contractile ability and cause local vasodilation,In this disease, the peripheral vascular blood flow everywhere in the body often increases twofold to threefold leads to peripheral edema ,cardiac failure due to increase cardiac output so much and others symptoms relate to increase the peripheral vascular blood flow.

*Special Examples of Acute "Metabolic Control of Local Blood Flow"

*Reactive Hyperemia;When the blood supply to a tissue is blocked for a few seconds to as long an hour or more and then is unblocked, blood flow through the tissue usually increases immediately to four to seven times normal; this increased flow will continue for a few seconds if the block has lasted only a few seconds but sometimes continues for as long as many hours if the blood flow has been stopped for an hour or more. After short periods of vascular occlusion, the extra blood flow during the reactive hyperemia phase lasts long enough to repay needs of tissues for oxygen and

others nutrients.

*Active Hyperemia. When any tissue becomes highly active, such as an exercising muscle, a gastrointestinal gland during a hyper secretory period, or even the brain during rapid mental activity, the rate of blood flow through the tissue increases.

The increase in local metabolism rate causes the cells to devour tissue fluid nutrients extremely rapidly and also to release large quantities of vasodilator substances. The result is to dilate the local blood vessels and increase local blood flow. In this way the active tissue receives the additional nutrients required to its new level of function.

The local mechanisms for controlling tissue blood flow can dilate only the very small arteries and arterioles (micro vascular parts of circulation)in each tissue because tissue cell vasodilator substancesor tissue cell oxygen deficiency can reach only these vessels.

when blood flow through a micro vascular portion of the circulation increases, this secondarily entrains another mechanism that does dilate the larger arteries by follow mechanisms:

The endothelial cells lining the arterioles and very small arteries synthesize several substances that, when released, can affect the degree of relaxation or contraction of the arterial wall . The most important of these is a vasodilator substance called endothelium derived relaxing factor (EDRF), which is composed principally of nitric oxide.

Note;Damage of endothelium cells cause release substance called (endothelin) a powerful vasoconstrictor substance, the release of local endothelin helps to prevent extensive bleeding from arteries.

Long-Term Blood Flow Regulation

most of the mechanisms for local blood flow regulation act within a few seconds to a few minutes after the local tissue conditions have changed. even after full activation of these acute mechanisms, the blood flow usually is adjusted only about three quarters of the way tothe exact of the tissues needs.

For instance, when the arterial pressure suddenly is increased from 100 to 150 mm Hg,in this moment the blood flow increases about 100 percent Immediately, then within 30 seconds to 2 minutes, the flow decreases back to about 15 per cent toward normal.

This illustrates the rapidity of the acute mechanisms for local blood flow regulation, but at the same time, it demonstrates that the regulation is still incomplete because there remains an excess 15 percent increase in blood flow.over a period of hours, days, and weeks, along-term type of local blood flow regulation developsin addition to the acute regulation. This long-term regulation gives far more complete regulation.

Mechanism of Long-Term Regulation Change in “Tissue Vascularity"

the arterioles and capillary vessels usually increase in both innumber and size within a few weeks to match the needs of the tissues.

*if the metabolism in agiven tissue is increased for a long period

Vascularity of the tissues increases.

*if the metabolism is decrease in a given tissues for long term

Vascularityof the tissue decreases.

*increase the vascularityof the tissues which caused by the mechanisms of long term regulation require factories for the formation of new blood vessels; these factories arevascular endothelial growth factor(VEGF) fibroblast growth factor, and angiogenin.

The formation of new blood vessels and also the final degree of response is much better in younger tissues than in older.

Role of Oxygen in Long-Term Regulation.

Oxygen is important not only for acute control of local blood flow but also for long-term control as important stimulant for angiogenic factor to make new blood vessels in oxygen deficiency.

1)One example of this is increased vascularity in tissues of animals that live athigh altitudes, where the atmospheric oxygen is low.

2)second example is in premature human babies put into oxygen tents for therapeutic purposes. The excess oxygen causes immediate cessation of new vascular growth in the retina of the premature baby’s eyes and even causes degeneration of some ofthe small vessels that already have formed. Then when the infant is taken out of the oxygen tent, there is extensive overgrowth of new vessels in the retina due to the sudden decrease in available oxygen, there is often so much overgrowth that the retinal vessels.grow out from the retina into the eye’s vitreous humor and this eventually causes blindness. (This condition is called Retrolental fibroplasia).

**Development of Collateral Circulation—A Phenomenon of Long

Term Local Blood Flow Regulation.

When an artery or a vein of specific tissues is blocked, the blood supply also blocked,which will lead to formation of a new vascular channel usually develops around the blockage and allows at least partial resupply of blood to the affected tissue.

The most important example of the development of collateral blood vessels occurs after thrombosis of oneof the coronary arteries, if the occlusion of the coronary artery occurs gradually and slowly enough to develop collateral circulation and prevents the myocardial infarction.

But sometimes the occlusion occurs suddenly and rapidly, therefore

No Times to develops collateral circulation.


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